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"STRAINS" IN HYDATINA SENTA.

D. D. WHITNEY.

In a former paper results of experiments upon two races of the rotifer *Hydatina senta* were given in regard to the production of one hundred generations of females without the appearance of males in either race. These experiments have been extended further for about seventeen months and as they are concluded it seems desirable to record the results obtained partly as a confirmation of the earlier conclusions and partly because they form evidence which shows that there exists different races or strains or lines within this particular species of *Hydatina senta*.

In the former paper it was shown how readily male-producing females could be produced in newly made dilute uncooked horse manure cultures and also how readily the male-producing females could be repressed in newly made concentrated cooked horse manure cultures.

In the present paper the parallel history of three races of rotifers *A*, *B*, and *C* is given. Races *B* and *C* are the same races upon which the former conclusions were based while race *A* is an additional one. Races *A* and *B* are sister races, both having developed from one fertilized egg while race *C* is unrelated to races *A* and *B* except in as far as all three races came from the same general culture of rotifers which was originally collected at Grantwood, New Jersey, in 1906.

Races *A* and *B* were always conducted in a parallel series but race *C* was not put into the parallel series until it was in the 36th generation. During this early period of the three races before they were all put into the parallel series the food was from miscellaneous protozoa cultures of various ages made in dilute uncooked horse manure media. The summary of the early history of these three races before they were all conducted in the parallel series is recorded in Table I. The percentage of male-producing females of races *A* and *B* are practically equivalent, while that of race *C* is much lower.

TABLE I.

Showing the number of female- and male-producers in the three races *A*, *B*, and *C*, from their origin to the time at which parallel records were taken. Female-producers are designated ♀♀, male-producers ♂♀.

Race.	Generations.	No. of ♀♀.	No. of ♂♀.	Per Cent. of ♂♀.	Time.	Food.
A	1–144	1,188	181	13.22+	Oct. 6, 1908, to Aug. 31, 1909.	Dilute uncooked horse manure media, 7–28 days old. Miscellaneous protozoa growing in them.
B	1–146	1,224	167	12.00+	Oct. 6, 1908, to Aug. 31, 1909.	
C	1– 35	210	10	4.54+	June 16, 1909, to Aug. 31, 1909.	

September 3, 1909, these three races *A*, *B*, and *C* were started in a parallel series under as identical external conditions as possible. At the beginning of this parallel series the generations were renumbered and the beginning generation of each of the races in this series is called No. I. Ten young females from each

TABLE II.

Race *C*.

Generation.	No. of ♀♀.	No. of ♂♀.	Per Cent. of ♂♀.	Time.	Food.
1	9	3	25	June 16, 1909, June 18, 1909.	Same as Table I.
2	20	0	0	June 18, 1909, June 20, 1909.	
3	16	4	20	June 21, 1909, June 22, 1909.	
4	8	2	20	June 24, 1909, June 26, 1909.	
Partial summary.	53	9	14.51+		
5–34	150	0	0	June 26, 1909, Aug. 30, 1909.	
35	7	1	12.5	Aug. 30, 1909, Sept. 1, 1909.	
Total summary.	210	10	4.54+		

Detailed history of race *C* throughout the first 35 generations, which is also summarized in Table I.

generation of each race were isolated at the same time and each female placed in a Syracuse watch glass and allowed to mature and to produce daughter females. Then this process was repeated for 345 generations. All the females at each isolation were placed in the same quantity of tap water to which was added the same amount of food culture that was taken from one food jar. The watch glasses in which the rotifers lived always were in three stacks side by side at room temperature. Practically all external influences were as identical as it was possible to make them.

The detailed observations are given in Table III. in parallel columns and the summary is given in Table IV.

At the end of Table I., races *A* and *B*, which up to this time were fed on various protozoa cultures, were practically identical in regard to the percentages of male-producing females in each race, but at the beginning of Tables III. and IV. when the two races were subjected to uncooked concentrated food culture media a decided change occurred. Race *A* retained and even exceeded its former rate of production of male-producing females, but in race *B* the rate was very perceptibly lowered. Race *C* lowered slightly its rate of male-producing females. This occurred during the first 56 generations. From the 57th to the 345th generation in races *A* and *C* and to the end of race *B*, the 239th generation, concentrated cooked food media was used and caused a decided lowering of the production of male-producing females in all races. In race *C* this was reduced to zero, in race *B* to less than 1 per cent., and in race *A* to about 3.5 per cent.

This confirms the earlier results in showing that it is possible by external conditions to repress entirely the production of male-producing females in some races of this rotifer for a long period of time. In race *C* the male-producing females were repressed for 280 generations and then reappeared when the food media was made too dilute accidentally.

If these three races were exactly alike in their power to produce male-producing females and all were subjected to the same external conditions they ought to produce such male-producing females at the same rate. However, as the above observations show that the rates of production of male-laying females vary

TABLE III.

Showing number of female- and male-producers in a parallel series of 345 generations in the three races *A*, *B*, and *C*. Generations 1–56 show the detailed results when the three races were fed upon concentrated uncooked food media and generations 57–345 show the detailed results when the same three races were fed upon concentrated cooked media.

Generation.	Race *A*.		Race *B*.		Race *C*.	
	No. of ♀ ♀.	No. of ♂ ♀.	No. of ♀ ♀.	No. of ♂ ♀.	No. of ♀ ♀.	No. of ♂ ♀.
1	5	0	6	0	7	0
2	8	2	10	0	10	0
3	9	0	10	0	9	0
4	9	0	9	0	9	0
5	9	0	8	0	9	0
6	9	0	9	0	9	0
7	9	0	9	0	9	1
8	10	0	9	0	10	0
9	8	2	10	0	10	0
10	8	2	10	0	9	1
11	9	1	10	0	10	0
12	10	0	10	0	10	0
13	10	0	10	0	10	0
14	7	3	10	0	9	1
15	9	1	9	1	10	0
16	7	3	8	1	10	0
17	10	0	10	0	10	0
18	9	1	10	0	10	0
19	10	0	9	0	9	1
20	9	1	10	0	10	0
21	8	2	10	0	8	2
22	8	2	9	1	10	0
23	9	1	8	1	10	0
24	8	2	10	0	10	0
25	9	1	10	0	10	0
26	9	1	9	1	9	1
27	5	5	10	0	10	0
28	10	0	10	0	9	0
29	10	0	10	0	9	1
30	8	2	10	0	10	0
31	5	5	9	1	10	0
32	10	0	8	2	10	0
33	10	0	10	0	10	0
34	4	6	10	0	10	0
35	6	4	9	0	10	0
36	6	3	10	0	10	0
37	9	1	10	0	10	0
38	8	2	10	0	10	0
39	9	1	10	0	9	1
40	1	9	6	4	6	4
41	7	3	10	0	10	0
42	8	2	10	0	10	0
43	7	3	10	0	10	0
44	7	3	10	0	9	1
45	7	1	9	0	9	0
46	7	3	10	0	10	0
47	7	3	9	1	10	0

TABLE III.—*Continued.*

Generation.	Race *A*.		Race *B*.		Race *C*.	
	No. of ♀♀.	No. of ♂♀.	No. of ♀♀.	No. of ♂♀.	No. of ♀♀.	No. of ♂♀.
48	7	3	10	0	9	1
49	6	3	9	1	10	0
50	7	3	9	1	10	0
51	7	3	10	0	10	0
52	7	2	10	0	10	0
53	10	0	10	0	10	0
54	9	1	10	0	10	0
55	10	0	10	0	9	1
56	6	4	9	1	8	2
57	10	0	10	0	10	0[1]
58	10	0	10	0	10	0
59	8	2	10	0	10	0
60	4	6	10	0	10	0
61	8	2	10	0	10	0
62	4	6	10	0	10	0
63	7	2	10	0	10	0
64	10	0	10	0	10	0
65	10	0	10	0	10	0
66	9	1	10	0	10	0
67	8	2	10	0	10	0
68	10	0	10	0	10	0
69	10	0	10	0	10	0
70	10	0	10	0	10	0
71	5	3	8	0	10	0
72	10	0	10	0	10	0
73	10	0	10	0	10	0
74	10	0	10	0	10	0
75	10	0	10	0	10	0
76	10	0	10	0	10	0
77	10	0	10	0	10	0
78	10	0	10	0	10	0
79	10	0	10	0	10	0
80	10	0	10	0	10	0
81	10	0	10	0	10	0
82	9	1	10	0	10	0
83	10	0	10	0	10	0
84	10	0	10	0	10	0
85	10	0	10	0	10	0
86	10	0	10	0	10	0
87	10	0	10	0	10	0
88	10	0	10	0	10	0
89	10	0	10	0	10	0
90	10	0	10	0	10	0
91	9	1	10	0	10	0
92	10	0	10	0	9	0
93	10	0	10	0	10	0
94	10	0	10	0	10	0
95	10	0	10	0	10	0
96	10	0	10	0	10	0
97	10	0	10	0	10	0
98	10	0	10	0	10	0
99	10	0	10	0	10	0

[1] Concentrated cooked horse manure media began to be used.

TABLE III.—*Continued.*

Generation.	Race *A.*		Race *B.*		Race *C.*	
	No. of ♀♀.	No. of ♂♀.	No. of ♀♀.	No. of ♂♀.	No. of ♀♀.	No. of ♂♀.
100	9	1	10	0	10	0
101	10	0	10	0	10	0
102	10	0	10	0	10	0
103	10	0	10	0	10	0
104	10	0	10	0	10	0
105	9	1	10	0	10	0
106	10	0	10	0	10	0
107	10	0	10	0	10	0
108	10	0	10	0	10	0
109	10	0	10	0	10	0
110	10	0	10	0	10	0
111	10	0	10	0	6	0
112	10	0	10	0	10	0
113	10	0	10	0	10	0
114	10	0	10	0	10	0
115	10	0	10	0	10	0
116	10	0	10	0	10	0
117	10	0	10	0	10	0
118	10	0	10	0	10	0
119	10	0	10	0	10	0
120	10	0	10	0	10	0
121	10	0	10	0	10	0
122	10	0	10	0	10	0
123	10	0	10	0	10	0
124	10	0	10	0	10	0
125	10	0	10	0	10	0
126	10	0	10	0	10	0
127	10	0	10	0	10	0
128	10	0	10	0	10	0
129	10	0	10	0	10	0
130	10	0	10	0	10	0
131	10	0	10	0	10	0
132	10	0	10	0	10	0
133	10	0	10	0	10	0
134	10	0	10	0	10	0
135	10	0	10	0	10	0
136	10	0	10	0	10	0
137	10	0	10	0	10	0
138	10	0	10	0	10	0
139	10	0	10	0	10	0
140	10	0	10	0	10	0
141	10	0	10	0	10	0
142	10	0	10	0	10	0
143	10	0	10	0	10	0
144	10	0	10	0	10	0
145	10	0	10	0	10	0
146	10	0	10	0	10	0
147	10	0	10	0	10	0
148	10	0	10	0	10	0
149	10	0	10	0	10	0
150	10	0	10	0	10	0
151	10	0	10	0	10	0
152	10	0	10	0	10	0
153	10	0	10	0	10	0

TABLE III.—*Continued.*

Generation.	Race *A*.		Race *B*.		Race *C*.	
	No. of ♀♀.	No. of ♂♀.	No. of ♀♀.	No. of ♂♀.	No. of ♀♀.	No. of ♂♀.
154	10	0	10	0	10	0
155	10	0	10	0	10	0
156	10	0	10	0	10	0
157	10	0	10	0	10	0
158	10	0	10	0	10	0
159	10	0	10	0	10	0
160	10	0	10	0	10	0
161	10	0	10	0	10	0
162	10	0	10	0	10	0
163	10	0	10	0	10	0
164	10	0	10	0	10	0
165	10	0	10	0	10	0
166	9	1	10	0	10	0
167	9	1	10	0	10	0
168	10	0	10	0	10	0
169	10	0	10	0	10	0
170	10	0	10	0	10	0
171	10	0	10	0	10	0
172	10	0	10	0	10	0
173	10	0	10	0	10	0
174	10	0	10	0	10	0
175	10	0	10	0	10	0
176	10	0	10	0	10	0
177	10	0	10	0	10	0
178	10	0	10	0	10	0
179	10	0	10	0	10	0
180	10	0	10	0	10	0
181	10	0	10	0	10	0
182	10	0	10	0	10	0
183	10	0	10	0	10	0
184	10	0	10	0	10	0
185	10	0	10	0	10	0
186	10	0	10	0	10	0
187	10	0	10	0	10	0
188	10	0	10	0	10	0
189	10	0	10	0	10	0
190	8	2	10	0	10	0
191	10	0	10	0	10	0
192	10	0	10	0	10	0
193	2	0	2	0	1	0
194	1	0	1	0	1	0
195	4	0	10	0	10	0
196	6	0	8	0	3	0
197	10	0	10	0	10	0
198	10	0	10	0	10	0
199	10	0	10	0	10	0
200	10	0	10	0	10	0
201	10	0	10	0	10	0
202	10	0	10	0	10	0
203	9	1	10	0	10	0
204	9	1	10	0	10	0
205	10	0	10	0	10	0
206	10	0	10	0	10	0
207	10	0	10	0	10	0

Table III.—*Continued.*

Generation.	Race *A*.		Race *B*.		Race *C*.	
	No. of ♀♀.	No. of ♂♀.	No. of ♀♀.	No. of ♂♀.	No. of ♀♀.	No of ♂♀.
208	10	0	10	0	10	0
209	10	0	10	0	10	0
210	10	0	10	0	10	0
211	10	0	10	0	10	0
212	10	0	9	1	10	0
213	10	0	10	0	10	0
214	10	0	10	0	10	0
215	10	0	10	0	10	0
216	8	0	8	0	8	0
217	9	1	10	0	10	0
218	10	0	10	0	10	0
219	10	0	10	0	10	0
220	10	0	10	0	10	0
221	10	0	10	0	10	0
222	5	0	4	0	10	0
223	10	0	10	0	10	0
224	10	0	10	0	10	0
225	10	0	10	0	10	0
226	10	0	9	1	10	0
227	1	0	1	0	1	0
228	10	0	10	0	10	0
229	10	0	10	0	10	0
230	10	0	4	6	10	0
231	10	0	10	0	10	0
232	10	0	5	0	10	0
233	10	0	10	0	10	0
234	7	0	4	0	9	0
235	1	0	2	0	10	0
236	4	0	1	0	3	0
237	10	0	1	0	10	0
238	10	0	4	0	10	0
239	10	0	0	0	9	0
240	10	0	Died.		10	0
241	3	0			10	0
242	4	0			10	0
243	10	0			10	0
244	8	2			10	0
245	10	0			10	0
246	10	0			10	0
247	10	0			10	0
248	10	0			10	0
249	10	0			10	0
250	10	0			10	0
251	10	0			10	0
252	9	0			10	0
253	10	0			10	0
254	9	0			9	0
255	10	0			10	0
256	6	0			9	0
257	10	0			10	0
258	10	0			10	0
259	10	0			10	0
260	10	0			10	0
261	10	0			10	0

TABLE III.—*Continued.*

Generation.	Race *A.*		Race *B.*		Race *C.*	
	No. of ♀♀.	No. of ♂♀.	No. of ♀♀.	No. of ♂♀.	No. of ♀♀.	No. of ♂♀.
262	7	0			10	0
263	9	0			10	0
264	9	0			10	0
265	10	0			10	0
266	10	0			10	0
267	10	0			10	0
268	10	0			10	0
269	10	0			10	0
270	10	0			10	0
271	10	0			10	0
272	10	0			10	0
273	10	0			10	0
274	7	3			10	0
275	10	0			10	0
276	10	0			10	0
277	10	0			10	0
278	10	0			10	0
279	10	0			10	0
280	8	0			10	0
281	9	1			10	0
282	8	2			10	0
283	8	2			10	0
284	10	0			10	0
285	4	6			10	0
286	5	4			10	0
287	9	1			10	0
288	8	2			10	0
289	6	0			10	0
290	7	0			7	0
291	6	1			9	0
292	8	0			2	0
293	9	0			10	0
294	10	0			10	0
295	4	0			9	0
296	4	0			9	0
297	1	0			9	0
298	4	1			9	0
299	4	5			4	0
300	8	0			8	0
301	7	0			10	0
302	10	0			10	0
303	9	0			8	0
304	10	0			10	0
305	9	0			8	0
306	10	0			8	0
307	8	0			9	0
308	4	0			7	0
309	6	0			10	0
310	7	0			10	0
311	10	0			10	0
312	5	0			5	0
313	5	0			5	0
314	5	0			5	0
315	3	2			5	0

TABLE III.—*Concluded.*

Generation.	Race *A.*		Race *B.*		Race *C.*	
	No. of ♀♀.	No. of ♂♀.	No. of ♀♀.	No. of ♂♀.	No. of ♀♀.	No. of ♂♀.
316	4	1			5	0
317	5	0			5	0
318	5	0			5	0
319	10	0			10	0
320	8	2			10	0
321	5	0			5	0
322	5	0			5	0
323	4	1			5	0
324	5	0			5	0
325	5	0			10	0
326	9	1			10	0
327	6	2			10	0
328	3	0			10	0
329	9	1			10	0
330	10	0			10	0
331	7	3			10	0
332	10	0			10	0
333	8	2			10	0
334	6	4			10	0
335	8	0			10	0
336	8	2			10	0
337	8	2			10	0
338	9	1			10	0
339	10	0			10	0
340	10	0			10	0
341	10	0			10	0
342	10	0			10	0
343	4	2			10	0
344	9	0			10	0
345	5	1			10	0
346	6	0			8	2[1]
347	8	0			10	0
348	5	0			9	1
349	3	0			9	1

in the three strains, *A*, *B*, and *C*, when all external conditions are identical the only conclusion that can be drawn is that the three strains differ at least in regard to this single characteristic. Perhaps they all may be potentially alike in their capacity to produce male-laying females but some races may be more easily effected than other races by the influence which causes male-producing females to be produced.

Whenever races *A* and *B* were put into newly made diluted uncooked culture media in battery jars great numbers of fertilized eggs were produced in both races. From general observations they seemed to be produced in equal numbers, thus seeming to form evidence that these two races were potentially alike in their power to produce male-producing females but when conditions were unfavorable they differed, as shown in the parallel series, in their responsiveness to the influences that so acted upon the females as to cause them to produce male-producing daughter females. However, when race *C* was put into newly made uncooked culture media in battery jars very few fertilized eggs were produced, thus seeming to show either that this race *C* was potentially different from the other two races in its capacity to produce male-producing females or that it was not as easily acted upon by the male-producing female influences as were races *A* and *B*. Notwithstanding this fact that race *C* produced very few male-producing females when put into battery jars containing dilute uncooked horse manure media it should be stated that in the early history of race *C* it had as high a percentage of male-producing females in the first four generations as was found in either race *A* or *B*, Table II. The race was isolated from a general culture jar in which an abundance of males were appearing at the time of isolation. Beginning with generation five very few males appeared thereafter. This early history shows that race *C* at one time was as potential in its power to produce male-producing females as races *A* and *B*, but whether it later lost this power or never was again subjected to as favorable influences for the production of male-producing females it is impossible to state. Whatever may be the true explanation of this divergence in the male-producing female rates of the three races it surely indicates a difference in the races either in their capacity to produce male-producing females or their responsiveness to the influences that cause male-producing females to be produced.

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[1] Food media was diluted accidentally.

Punnett concluded that he found "sex strains" in *Hydatina senta* which differed in their power to produce males and even concluded that he found some strains that produced no males. It is very possible that such maleless strains were really like race *C* in the above experiments. From observations and experiments published in an earlier paper ('07), it was shown that no pure female strains could be found. The results of the present experiments corroborate this earlier conclusion. However, the evidence at that time showed no strains of any kind but the

Table IV.

Summary of Table III. showing the influence of concentrated uncooked horse manure media, containing various protozoa and concentrated cooked horse manure media containing only the protozoa, *Polytoma*.

Generations.	Race *A*.			Race *B*.			Race *C*.			Time.	Food.
	No of ♀♀.	No. of ♂♀.	Per Cent. of ♂♀.	No. of ♀♀.	No. of ♂♀.	Per Cent. of ♂♀.	No. of ♀♀.	No. of ♂♀.	Per Cent. of ♂♀.		
1–56	445	100	18.34+	529	16	2.93+	533	18	3.26+	Sept. 3, 1909, to Jan. 16, 1910.	Uncooked concentrated horse manure media, 2–5 days old. *Polytoma* and other protozoa.
57–345	2,565	92	3.46+				2,749	0	0	Jan. 16, 1910, to Nov. 15, 1911.	
57–238				1,731	8	0.45+				Jan. 16, 1910, to Mar. 6, 1911.	Cooked concentrated horse manure media, 1½–3 days old. Pure culture of *Polytoma*.

present evidence collected from observations extending over a period of about three years and including 300–500 parthenogenetic generations shows very clearly that strains exist which differ in their percentage of male-producing females.

Moreover, the two sister strains *A* and *B* which developed from the same fertilized egg differed in their longevity. Strain *B* died out from general exhaustion in the 384th parthenogenetic generation, while strain *A* is still alive in the 504th parthenogenetic generation, although in a very weak and exhausted condition.

Shull has compared some of the New York strains of *Hydatina senta* with a strain from Baltimore and has found a decided difference in the rate of production of males in the two strains. He says, "It is safe to say, therefore, that we have here two pure lines that differ from one another in a fairly constant manner, and the difference is an internal one."

SUMMARY.

1. The production of male-producing females can be partly or wholly repressed by external conditions in parthenogenetic races of *Hydatina senta*.

2. The parthenogenetic strains are shown to be distinct because under identical external conditions they differ in their power to produce male-producing females. This may indicate that they differ in their potentiality of producing male-producing females or that they differ in degree of responsiveness to the influences which cause male-producing females to be produced. The latter alternative seems more probable.

3. The two sister parthenogenetic strains developing from one fertilized egg differed in their longevity. One lived about a year longer and produced over one hundred more generations than the other.

BIOLOGICAL LABORATORY,
WESLEYAN UNIVERSITY,
MIDDLETOWN, CONN.,
January 3, 1912.

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